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REVIEW ON PERFORMANCE EVALUATION TEST METHOD OF EVACUATED TUBE COLLECTOR (ETC) SOLAR WATER HEATING SYSTEM FOR DOMESTIC PURPOSE

H. N. KADEVAL, DESAI MUKESH K, CHAUDHARY DALPAT K & A. D. DESHPANDE

College of Renewable Energy & Environmental Engineering, S. D. Agricultural University,

Sardarkrushingar, Gujarat, India

ABSTRACT

Solar energy is the most readily available and free source of energy, which can be used to generate heat energy though solar thermal technology. Different Tests selected for the performance evaluation were Outdoor no-flow exposure test, Static pressure leakage test, Thermal efficiency test on evacuated glass-tube. The tests are carried out to check and evaluate the durability, integrity, capability and efficiency of solar evacuated tube collector.

KEYWORDS: Absorber, Domestic, Passive, Thermos Phonic, No-flow Exposure, Evacuated Tube Collector

INTRODUCTION

INTRODUCTION TO ETC SOLAR WATER HEATER

Evacuated tube collector are made up of glass tube that the air has been evacuated out. Actually each tube is made up of a glass tube within glass tube. Each tube is made of two layers of strong borosilicate glass. So that there is no air in tubes to prevent heat loss through convection and radiation. The vacuum helps to retain the heat that has been collected allowing a much greater heat gain.

LITERATURE REVIEW of ETC SOLAR WATER HEATER

Aste N. et al. (September 2013) solar water heaters are non-polluting systems, which can contribute to tackle the increasing energy demand without affecting the environment. The reduction of greenhouse gases (GHGs) emission, along with a decreased dependency on expensive and polluting fossil fuels, are the main advantages of these systems. This paper describes the status of solar water heating (SWH) systems, technologies, applications and considerations about their feasibility and cost effectiveness. An introduction about the solar thermal systems and their recent market growth is presented. This is followed by a description of the different types of SWH systems based both on different configurations (viz. natural convection and forced mode) and on different collector technologies (including flat-plate and evacuated tube), described in order to show the extent of their applicability. Other main distinctive parameters for optical and thermal analysis of the collectors are presented and a description of the methods used to evaluate their performance is provided. Finally, the financial feasibility of different kinds of SWH technologies and the potential for CO_2 emission reduction are discussed, showing that SWH systems can be successfully used for domestic hot water and space heating applications with significant benefits in terms of energy saving, environmental impact and even cost-effectiveness.

G.L. Morrison *et al*. (January–March 2004) Evacuated tube solar collectors have better performance than flat-plate solar collectors, in particular for high temperature operations. A number of heat extraction methods from all-glass evacuated tubes have been developed and the water-in-glass concept has been found to be the most successful due to its simplicity and low manufacturing cost. In this paper, the performance of a water-in-glass evacuated tube solar pre-heater is investigated using the International Standard test method ISO 9459-2 for a range of locations. Factors influencing the operation of water-in-glass collector tubes are discussed and a numerical study of water circulation through long single-ended thermo syphon tubes is presented. Preliminary numerical simulations have shown the existence of inactive region near the sealed end of the tube which might influence the performance of the collector.

Xinyu Zhang *et al.(* August 2014) Experimental performance evaluation and comparative analyses based on heat extraction of direct-flow coaxial evacuated-tube solar collectors with and without heat shields are presented in this paper. A test system to evaluate the thermal performance of medium-temperature solar collectors was developed. The experimental analysis shows the evacuated-tube solar collector performed better with a heat shield, especially at higher working temperatures. The collection efficiency of the solar collector with a heat shield was 54.70% at the highest inlet temperature of 123.9 °C during the test period, which is 31.49% higher than for the solar collector without a heat shield. The calculated heat-loss coefficient for the evacuated-tube solar collector with a heat shield was 1.86 W/(m^2 K), which is an improvement of 50.80% compared with that of the collector without a heat shield.

J.M. Chang *et al*. (2004) Conventionally, the overall performance rating of a thermosyphon solar water heater considers the thermal performance of the system during the energy-collecting phase and the system cooling loss during the cooling phase. However, this study suggests that the performance rating should also take the heat removal efficiency of the system during the system application phase into consideration. This study modifies the CNS 12557 B7276 test standard and employs a precise, on-line operation to derive the heat removal efficiency of a system. The thermal performance and heat removal efficiency of 12 systems with capacities in the range of 102–446 L are evaluated. An efficiency coefficient, η_0, is defined, which represents the synthesis of the characteristic thermal performance, η_s^*, and the characteristic heat removal efficiency, η_R^*. The proposed modified efficiency coefficient is given by $\eta_0 = \eta_s^* \times \eta_R^*$, and represents the quasi-overall performance of a solar heating system. The coefficient provides an effective measure of the amount of energy provided to the user from a system which collects and stores heat from solar radiation. According to prevailing regulations in Taiwan, commercial solar heating products should have a value of η_s^* in excess of 0.5 in order to attract a government subsidy. The proposed modified efficiency, η_0, is a more practical and representative indication of the actual thermal performance of a system, and accordingly, the present study suggests that the regulations should adopt a value of $\eta_0 \geqslant 0.41$ as the standard for qualification rather than the current criterion of $\eta_s^* \geqslant 0.5$.

METHODOLOGY

Different test method are used to determine the efficiency and durability of ETC solar water heater system.

Pre-Conditioning Test

Fully assembled system filled with water shall be kept exposed to weather conditions for 16 days having daily solar irradiance on the plane of solar collectors more than 16 MJ/m^2. The days with solar irradiance lesser than this value shall not be counted. All parts of the system shall be inspected for any visual sign of degradation, deformation, ingress of moisture/dust, etc.

Outdoor No-Flow Exposure Test

Outdoor no-flow exposure test is done to check durability of a solar collector by inspecting it for 30days. The solar collector was mounted outdoors at an angle of 30º from horizontal. One of the fluid pipes of the solar collector is sealed to prevent cooling by natural circulation of air, whereas the other fluid pipe was left open to permit free expansion of air in the absorber. The collector was kept empty without any water. The collector was exposed until at least 30 days, these days need not be consecutive with a minimum irradiation of $4kwh/m^2/day$ have passed. The glazing of the collector cleaned periodically. The ambient air temperature was recorded to an accuracy of 0.5ºC and the total irradiance on the plane of the solar collector was noted using a pyronometer. Integrated values of data was recorded at every 30 min. The collector was visually inspected for any damage or degradation. Specially that of rubber material and black paint. The climatic conditions during the test, including daily irradiation, ambient temperature and rain fall were also noted.

Static Pressure Leakage Test

The purpose of this test is to ensure the integrity of tank to withstand the pressure. Initially, air bleed valve is kept open and it is ensured that all air is removed from the collector by circulating water through it. Thereafter, the solar Water Heating System (tank + collector) is filled with water. After filling the bleed valve and all other valves are closed hydraulic pressure of 0.2 kg/cm^2 is applied to system. The system is kept pressurized for a period of 30 min. After 30 minutes, all parts of the system especially the storage tank shall be inspected for visual sign of any leakages. Results of the test in terms of the initial and final reading of the pressure gauge, temperature of the water, duration of the test and the result of inspection shall be reported. With a view to suppress reverse flow during night. In such a case, the solar collector and part of piping would not play role in loosing heat from the tank during night as it does during the day. However, night time test would account for all thermal losses from the system.

Thermal Performance Test

The test method is based on a lumped capacitance model, where it is assumed that average water temperature in the storage tank characterizes the behaviour of the whole system whether the storage is well – mixed or stratified. The system performance is evaluated in two parts corresponding to its performance during daytime and separately during night time. Usually, the storage tank in solar water heating systems which are designed to work on the principle of thermosphonic flow is located at higher level than the top edge of the solar collector.

Thermal Efficiency Test

This test of solar collector was performed to evaluate the extent of their capability to provide useful heat under given climatic and operating conditions. The solar collector was tested over its operating temperature range under clear sky conditions for determining its efficiency. The measurement was carried out under steady state condition. Data points which satisfy the requirement given below were obtained for at least four inlet temperature spaced evenly over the operating range of the collector. One inlet temperature was selected such that the mean fluid temperature in the collector lies within ± 3ºC of the ambient temperature in order to obtain an accurate determination of thermal efficiency.

Total heat collected (KW)= $Q = m_w \times C_{pw} \times \Delta T$ (i)

Where, Q = amount of heat collected in kW

m_w = mass of water heated in one solar day

C_{pw} = specific heat of water, 4.18 kJ/kg °C

ΔT = the temperature deference of water,

$$\text{Collector efficiency} = \frac{Q}{Is \times A} \tag{ii}$$

Where, Is = Solar insolation on tilted surface,

A = solar collector area

CONCLUSIONS

Borosilicate glass are suitable to use in place of tube for design and fabrication of evacuated tube collector to reduce the cost of the system. The black color coated aluminum foil found suitable to use as a heat absorbing element in place of inner vacuum glass tube in the commercial systems.

Different test like preconditioning test, Static pressure leakage test, outdoor no flow exposure test,

Thermal performance test are used to carried out performance of all glass evacuated solar water heater system.

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